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WIND MAPPING OFFSHORE IN COASTAL MEDITERRANEAN AREA USING SAR IMAGES

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Abstract

Satellite observations of the ocean surface from Synthetic Aperture Radars (SAR) provide information about the spatial wind variability over large areas. This is of special interest in the Mediterranean, where spatial wind information is only provided by sparse buoys, often with long periods of missing data.

Here, we focus on evaluating the use of SAR for offshore wind mapping. Preliminary results from the analysis of SAR-based ocean winds in Mediterranean areas show interesting large scale wind flow features consistent with results from previous studies using numerical models and space borne wind data i.e. scatterometers with lower resolution.

Motivations

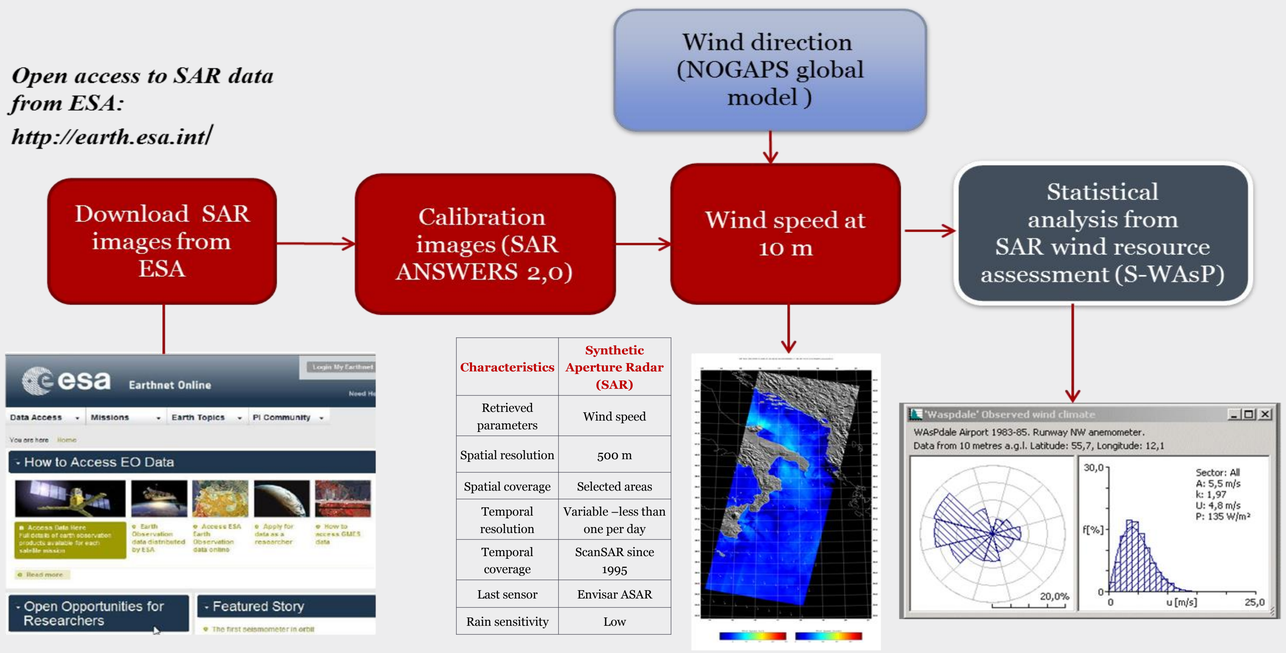
In the first phase of planning prospective offshore wind farms, it is of fundamental importance to choose suitable areas worth to be explored in detail.

To find such areas, suitable information on the long-term wind characteristics i.e. average wind speed, wind speed and direction frequency distributions and spatial variability are needed, especially in the coastal zone where offshore wind has the highest spatial and temporal variability.

SAR wind field maps have the advantage of providing higher spatial information (100m) with respect to space borne wind data from scatterometers such as QuikSCAT (~ 25 km)

Methodology

Open access to SAR data from ESA:
http://earth.esa.int/



Characteristics	Synthetic Aperture Radar (SAR)
Retrieved parameters	Wind speed
Spatial resolution	500 m
Spatial coverage	Selected areas
Temporal resolution	Variable –less than one per day
Temporal coverage	ScanSAR since 1995
Last sensor	Envisar ASAR
Rain sensitivity	Low

We use data from ENVISAT satellite by the European Space Agency (ESA).

In ScanSAR mode, the ASAR sensor is capable of scanning in a 400 km wide swath with a spatial resolution of 100 m.

Wind speed in the Mediterranean from March 2002 to April 2012 is retrieved at high resolution using the Johns Hopkins University, Applied Physics Laboratory (JHU/APL) software APL/NOAA SAR Wind Retrieval System (ANSWRS version 2.0).

The algorithm is initialized using wind directions determined by the Navy Operational Global Atmospheric Prediction System (NOGAPS) models interpolated in time and space to match the satellite data. NOGAPS data are available at 6-hour intervals mapped to a 1° latitude/longitude grid and the wind vectors from the lowest model level around 10 m above the are used.

The statistical analysis of SAR wind map, for a total of 3269 scenes, is performed with the Satellite –Wind Atlas Analysis and Application Program (S-WAsP) tool developed by Risø DTU. S-WAsP is a software for wind resource estimation based on SAR data.

Wind climatology and a case study

Observations. Three hourly wind data were available for the Lampedusa and Ustica Islands from the Italian Meteorological Service; hourly measurements at a 10m mast, located at the coastline, in the coastal town of Crotone were provided by the marine network of sensors of ISPRA (Institute for Environmental Protection and Research).

Figure 1 shows: The location of the observations; The resulting maps of mean wind speed in the Mediterranean and around the Calabria region, a long, narrow and mountainous peninsula in South Italy, where breezes and mountains play a major role for the local climate causing opposite wind variability at either side of the coast; and the comparisons between observations and SAR winds.

In the Mediterranean map, we note the channeling effect due to orographic features i.e. Sicily Channel, le Bocche di Bonifacio between Corsica and Sardinia; and in the Calabria map we note the high wind speed (in yellow) likely associated to the effect of the only valley that connects the Tyrrhenian Sea to the Ionian Sea. The pattern might represent both the channeling created either by the sea breeze or by the synoptic flow.

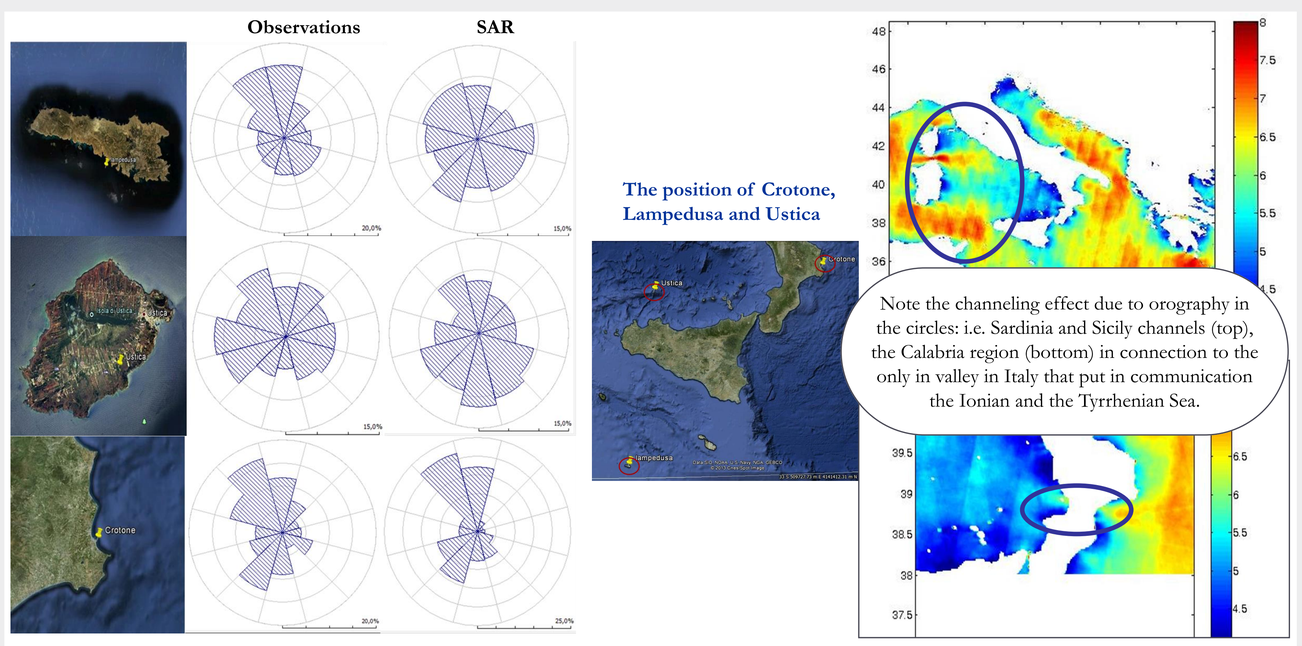


Figure 1 Wind Climatology: (Left) Comparison of the wind roses from SAR and observations at Lampedusa (top) and Ustica (middle) islands and the coastal site of Crotone in Calabria. (Right). Wind maps of the Mediterranean (top) and around Calabria (bottom) at 10 m. a.s.l.

Case study - Crotone 2009

Comparison of the wind direction input from NOGAPS

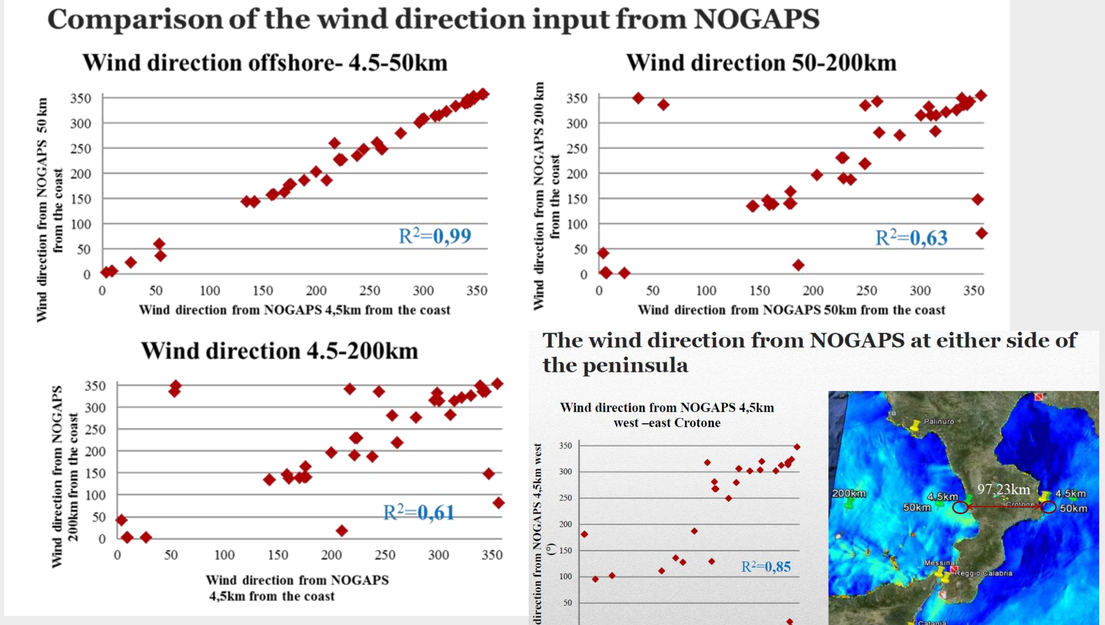


Figure 3. Correlation of NOGAPS wind directions between points at different distances.

The wind direction from NOGAPS at either side of the peninsula

Figure 2. Correlation of NOGAPS wind directions at two points at either side of the Calabria region.

NOGAPS DIRECTIONS AROUND NARROW PENINSULAS.

To investigate the suitability of wind directions from the NOGAPS model around peninsulas narrower that the model spatial resolution, we focus on the Calabria region and use a subset of 44 satellite images in year 2009 covering the area.

We selected points of the SAR images at distances of 4.5, 50 and 200 km at the two opposite sides of peninsulas (Figure 2).

Figure 3 illustrates that the correlation coefficient of NOGAPS wind directions at different distances varies from R^2=0.61 to R^2= 0.99 depending on the distance. The high correlation R^2=0.99 between 4.5 and 50 km, indicate that the points fall in the same grid mesh , confirming the limit of the NOGAPS horizontal resolution.

Another example is on the NOGAPS wind direction correlations at either side of the Calabria region at two points chosen 4,5 km offshore. The coefficient of correlation between NOGAPS data wind direction of two opposite sides of peninsulas, is R2= 0.85.

Also in this case, the high correlation confirms the limit of the NOGAPS horizontal resolution in presence of peninsulas narrower than the model grid resolution. Opposite winds during sea breeze days are not caught.

Therefore, in such cases, models with higher spatial resolution would probably be more appropriated and future work will address this issue.

Conclusions. We presented preliminary results from the analysis of SAR-based ocean winds in Mediterranean area at a spatial resolution of 500m, suitable for estimating the coastal wind climatology. Here, we showed the wind climatology for the Mediterranean obtained using wind data retrieved for the whole ENVISAT mission.

The resulting wind maps show reliable flow patterns induced by the orography i.e. flow channeling i.e. in the Sardinia channel and in connection to the only in Valley in Italy that put in communication the Ionian and the Tyrrhenian Sea. The SAR methodology is certainly useful as a guide to indicate prospective coastal areas where to carry on detailed measurements.

Work is in progress to study the accuracy of the ANSWRS 2.0 - SAR wind retrieval system, using as input the RAMS mesoscale model at 10 km resolution instead of the NOGAPS model, since NOGAPS is not able to catch i.e. the different seas breeze direction development at either sides of a peninsula narrower than its spatial resolution.